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(54) VACUUM INSULATED VESSELS

(71) We, THE BRITISH OXYGEN COMPANY LIMITED of Hammersmith House, London, W.6, England, a British company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to vacuum-insulated vessels. In particular it relates to vacuum-insulated vessels made from pieces of plastics material.

Known vacuum-insulated vessels include those constructed from glass and stainless steel. Each of these materials has certain disadvantages associated with its use in vacuum-insulated vessels. Glass vacuum-insulated vessels are fragile, have to be handled with care and are liable to crack if suddenly subjected to extremes of temperature. Stainless steel vessels are heavy, comparatively expensive to build and have a high thermal conductivity.

Plastics material, however, are particularly suitable for use in constructing vacuum-insulated vessels. They are lightweight and poor conductors of heat, but are much stronger than glass. Furthermore plastic vacuum-insulated vessels may be constructed at low cost.

Difficulties in production arise in attempting to use one piece of plastics material to form a complete body for a vacuum-insulated vessel. The vacuum-insulated vessel is therefore made from more than one piece, the pieces being joined together to form a body. When a vacuum-insulated vessel is used as a container for cold liquids the joints between the pieces are subjected to strains owing to expansion and contraction of the pieces, which strains may cause failure of the joints. In particular, it has been found that some joints crack when repeatedly cycled between ambient and very low temperatures. A construction has now been found in which all the joints are distant from the contents of the vessel, thus diminishing the strains to which the joints are subjected.

According to the present invention there is provided a vacuum-insulated vessel constructed from two or more pieces of plastics material, the vessel having inner and outer walls enclosing between them an evacuated space, one piece being a disc that forms the base portion of the outer wall and the other piece or pieces providing the whole inner wall and the rest of the outer wall, the outer wall including the or each vacuum-tight joint between the pieces.

The term "plastics material" as used throughout the specification is intended to include any synthetic or semi-synthetic condensation or polymerisation product, capable of being shaped, normally by the application of heat and pressure, or any composite material that includes any product of the type described above, have the properties, for example of strength and impermeability, required to withstand the conditions to which it would be subjected when used in a vacuum-insulated vessel. These conditions vary according to the use to which the vacuum-insulated vessel is put, so that the plastics material of choice will depend on this use.

Suitable plastics materials for the construction of a vacuum-insulated vessel include nylon, polycarbonate resins, acetal resins, and acrylonitrile-butadiene-styrene polymers.

One disadvantage of many plastics materials is that they are not as strong as metals and being poor conductors are liable to crack through strains caused by temperature differentials. However the strength of plastics material may be increased by including in it fibrous matter, for example glass fibre. Accordingly polyester resins reinforced with glass fibre are also suitable materials. One particularly suitable plastics material having a relatively high impermeability is a nylon reinforced with glass fibre.

By forming the vessel from two pieces only, with the joint therefore at the base portion of the outer wall there is provided a heat conducting path, *via* the outer and inner walls,

[*Price 25p*]

between the joint and the contents of the vessel. In serving as a base the disc may be raised in a position such that the vessel stands on a rim provided by the second piece.

Each piece of the vessel may be made to the shape required by, for example, moulding, or pressing a sheet of plastics material into shape. Preferably each sheet is formed by injection moulding. In such a construction there is only one joint, well insulated from the contents of the vessel.

The joint or joints between the pieces comprising the vessel may be made by methods well known in the art, which includes the use of adhesives and of welding techniques. Epoxy resins, are particularly suitable adhesives, as they have inherent resistance to cracks caused either by physical shock or by shrinkage or expansion of the pieces they bond together. An adhesive joint between the pieces may be made by cleaning the surfaces to be adhered, slightly roughening the surfaces, applying the adhesive to them, and then joining the pieces. If an epoxy resin is used, it may be cured at ambient or higher temperatures. A hot air blow pipe, for example, may be used when the pieces are joined by welding.

If the vessel comprises pieces of plastics materials which are not sufficiently impermable for the purpose required, then those pieces may be coated with metal, for example, aluminium, by means of, for example, vacuum deposition of the metal. A particularly suitable method of coating the plastics material with metal is to bond a sheet of metal foil to one of the surfaces of the plastics material, using an adhesive to make the bond. A particularly suitable plastics material is thus provided by a nylon reinforced with glass, having aluminium foil bonded to one of its surfaces. If the side of their walls adjacent to the evacuated space is the side chosen for coating then this can conveniently be done after the body of the vessel has been constructed and before it has been evacuated. The metallic layer has the advantage of also forming reflective insulative means. Alternatively the coating may be provided by laminating with another material. The coating may also help in reducing any tendency of the plastics material to out-gas, that is to evolve gas itself.

The vessel may also be provided with superinsulating material between its walls. By superinsulating material it is meant multiple layers of reflecting material provided with spacing means. For example, alternate layers of metal foil and nylon netting or glass mat, the metal foil providing insulation against radiative heat, and the nylon netting or glass mat providing insulation against conductive heat, may be used.

A suitable means of allowing evacuation of the space between the double walls is provided by a tube, for example, a lead tube, fitting in an aperture which may be in the base of the vessel, to communicate with the space. When the space has been evacuated the tube is sealed, and may be given a cap for its protection. Alternatively the means for allowing evacuation may be provided for a valve member, which may also be given a cap for protection.

The evacuated space may include a "getter", for example, charcoal, in order to adsorb gas that may infiltrate into the evacuated space. The "getter" may be included in, for example, a breather cap attached to the inner wall of the vessel.

The vessel may have a closure to reduce heat losses and to reduce evaporation of any cold liquid contained in the vacuum-insulated cavity. This closure may be a stopper or a bung that fits inside the inner wall of the vessel, or a cap that fits outside the outer wall of the vessel, or a member, one part of which fits inside the inner wall of, the other part of which fits outside the outer wall of, the vessel. To provide further vacuum-insulation, the closure may be a member which itself includes an evacuated space.

It is preferable that the container designed to contain cryogenic liquids, for example liquid nitrogen, is constructed such that it has a neck. Difficulties arise, however, in forming a vessel as described hereinbefore of such a shape that it has a neck. In particular complex and expensive tools are required to form the pieces.

According to another feature of the present invention there is provided a vacuum-insulated container constructed from a first vessel of the type described above, and a second vacuum-insulated vessel which forms the neck of the container and is constructed from two or more pieces of plastics material.

The neck vessel may include any number of features described hereinbefore with respect to a vessel in which contents may be placed.

The neck vessel may be permanently joined to the vessel in which contents may be placed by a method well known in the art, for example, by adhesives, by adhesives in combination with "O"-rings, or by a screw means enhanced by the use of an adhesive as a thread-filler.

Such containers have a vacuum-insulated cavity almost entirely enclosed by vacuum-insulation. Furthermore a long path may advantageously be provided for the conduction of heat along the joint between the two vessels.

One suitable form of neck vessel is a two-piece member in which one of the pieces is an annular disc which forms the base portion of the outer wall of the vessel, and the other piece forms the rest of the outer walls and the whole of the inner wall. Preferably the neck vessel is a two piece member, one piece providing most or all of the outer wall and the other piece providing the rest of the walls. The neck member can, if desired, be provided

with a cap or other closing means.

Vessels and containers according to the present invention are particularly suitable for storage of low temperature material, for example, liquefied gas such as liquid nitrogen. Sorptive material may be disposed inside the vessel to provide a storage medium for liquefied gas.

In general the vessels according to the present invention are cheap to construct, only simple tools being required in their construction and have a light weight. They are thus particularly easy to transport. Use of the preferred plastics material gives a plastic vacuum-insulated vessel or container according to this invention an excellent impermeability when compared with known plastics containers.

The present invention will now be described by way of example with reference to the accompanying drawings of which

Figure 1 is a sectional side elevation of one form of vacuum-insulated container;

Figure 2 is a sectional side elevation of a portion of a second form of vacuum-insulated container;

Figure 3 is a sectional side elevation of a portion of a third form of vacuum-insulated container; and

Figure 4 is a sectional side elevation of another form of vacuum-insulated container.

The vacuum-insulated container shown in Figure 1 comprises a double walled vessel 12 with an evacuated space 14 between its double walls, and a double walled neck vessel 16 with an evacuated space between its double walls. The neck vessel 16 includes a one piece shell 20 shaped to provide a centrally disposed tubular neck aperture 21 which leads to a wider aperture to receive the vessel 12. The shell 20 has an annular end piece 22 fitted to it by means of vacuum-tight joints 24 and 26. The vessel 12 includes a one piece shell 28 shaped to fit inside the neck vessel 16 and to provide a vacuum-insulated cavity 30. The shell 28 has fitted to it by a vacuum-tight joint 32 a disc-shaped end-piece 34 which provides the base of the vessel 12. Both the end pieces 22 and 34 have sealed lead tubes 36 which before sealing are used to evacuate the vessels 12 and 16. The lead tubes 36 are protected by caps 38. The vessel 12 fits inside the vessel 16 along a fluid-tight adhesive joint 40. To improve the performance of the vessels 12 and 16 layers 42 of super-insulating material are included within the double walls.

Other types of fluid tight joints 40 may be used to joint the contents vessel 12 and the neck vessel 16. For example, in Figure 2, wherein like parts are given the same reference numeral as in Figure 1, "O"-rings 44 and 46 fit in grooves in the vessel 12 with an adhesive joint 40 uniting the vessels 12 and 16. A further type of fluid tight joint 40 is shown in Figure 3, wherein like parts are given the same reference numerals as in Figure 1. The vessels 12 and 16 have coarse screw threads 48 by which they are joined, and an adhesive is provided to make the joint 40 permanent and fluid tight.

The form of vacuum insulated container shown in Figure 4 is generally similar to that shown in Figure 1, with like reference numerals used to indicate like parts in the two drawings. The neck vessel 16, however, is constructed from two pieces 50 and 52 of plastics material, the piece 50 being generally cylindrical and forming the outer wall of the vessel 16 and the piece 52 similarly forming the inner wall. The pieces 50 and 52 are joined by adhesives along the joints 54 and 56. In addition a breather cap 58 including an activated charcoal getter is joined to the inner wall at the base of the piece 28 within the evacuated space.

The pieces of plastics material 28, 34, 50 and 52 are formed from a glass-fibre reinforced nylon known under the name Maranyl A 190 (MARANYL is a registered trade mark) and are covered on their inner surfaces with aluminium foil. The superinsulant 42 comprises alternate layers of aluminium foil and glass mat.

The container may be constructed as follows. The pieces of Maranyl A 190 are formed to the appropriate shape by injection moulding; aluminium foil is bonded to the inner surface of each piece using an adhesive, the vessels 12 and 16 are assembled and joints 32, 54 and 56 made using an epoxy resin adhesive, the super-insulant 42 and the getter cap 58 being located before the joints are made; the vessels 12 and 16 baked out in a furnace, both of their pump down points 36 being connected to vacuum pumps to evacuate the spaces 14 and 18; the caps 38 are inserted on the tubes comprising the pump down points 36 after evacuation has been completed; and after the vessels 12 and 16 have been cooled they are mated along the joint 40 which is made using an epoxy resin adhesive.

WHAT WE CLAIM IS:—

1. A vacuum-insulated vessel constructed from two or more pieces of plastics material, the vessel having inner and outer walls enclosing between them an evacuated space, one piece being a disc which forms the base portion of the outer wall and the other piece or pieces providing the whole inner wall and the rest of the outer wall, and the outer wall including the or each vacuum-tight joint between the pieces.

2. A vacuum insulated vessel as claimed in claim 1 wherein the plastics material is a synthetic or semi-synthetic condensation or polymerisation product, capable of being shaped, normally by the application of heat or pressure, or is any composite material that includes such a synthetic or semi-synthetic condensation or polymerisation product.

3. A vacuum insulated vessel as claimed in claim 1 or claim 2, wherein the plastics material is a nylon, a polycarbonate resin, an acetal resin, or an acrylonitrile-butadiene-styrene polymer.

4. A vacuum insulated vessel as claimed in claim 3, wherein the plastics material is reinforced with fibrous material.

5. A vacuum insulated vessel as claimed in claim 4, wherein the fibrous material is provided by a glass fibre.

6. A vacuum insulated vessel as claimed in any preceding claim, wherein the plastics material is coated with a metal.

7. A vacuum insulated vessel as claimed in claim 6, wherein the coating is made by bonding metal foil to one of the surfaces of the plastics material using an adhesive to make the bond.

8. A vacuum insulated vessel as claimed in claim 6 or claim 7, wherein the metal is aluminium.

9. A vacuum insulated vessel as claimed in any preceding claim, wherein the plastics material is a nylon which is reinforced with glass fibre and which has aluminium foil bonded to one of its surfaces.

10. A vacuum insulated vessel as claimed in any preceding claim, wherein the joints are made by the use of an adhesive.

11. A vacuum insulated vessel as claimed in claim 10, wherein the adhesive is an epoxy resin.

12. A vacuum insulated vessel as claimed in any preceding claim which additionally includes superinsulating material as hereinbefore defined between its walls.

13. A vacuum insulated vessel as claimed in claim 12, wherein the superinsulating material comprises alternate layers of metal foil and nylon netting or glass mat.

14. A vacuum insulating vessel as claimed in any preceding claim which additionally includes a gas adsorption means between the walls.

15. A vacuum insulated container constructed from a first vessel as claimed in any preceding claim and a second vacuum insulated vessel which forms the neck of the container and is constructed from two or more pieces of plastics material.

16. A vacuum insulated vessel or container substantially as described herein with reference to Figures 1 to 4 of the drawings.

For the Applicants,
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1294995 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

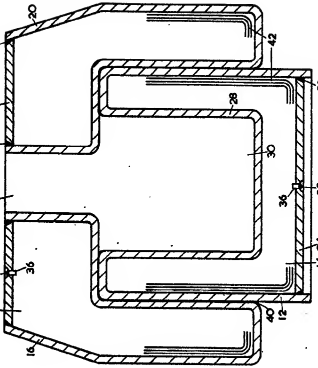


FIG.1

FIG.2

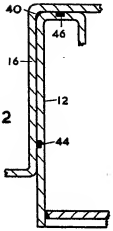
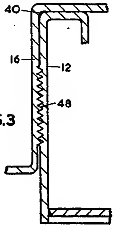


FIG.3



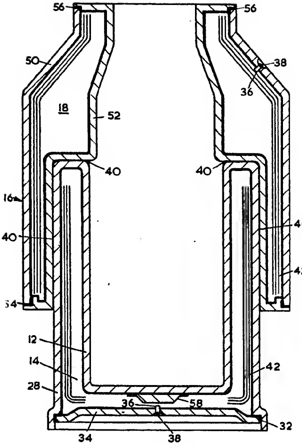


FIG. 4